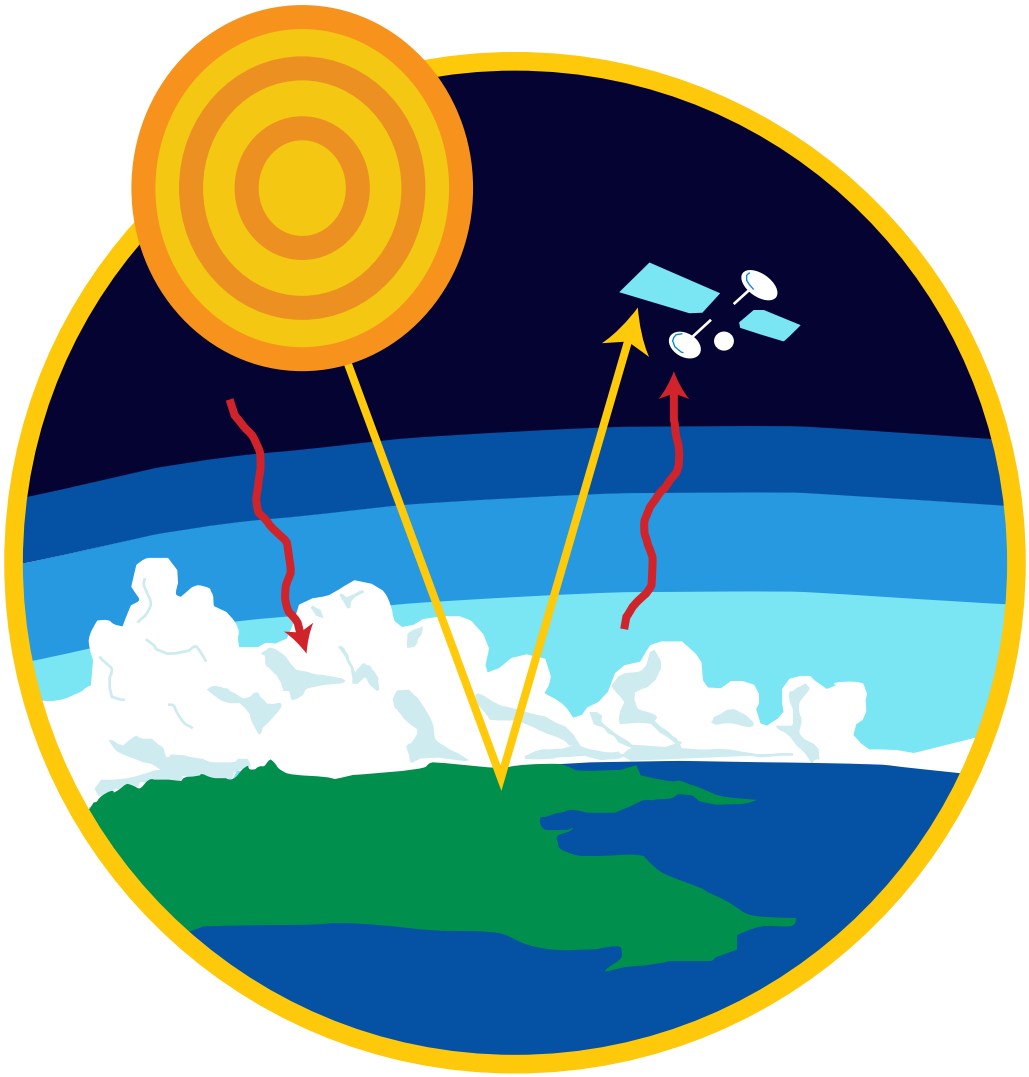
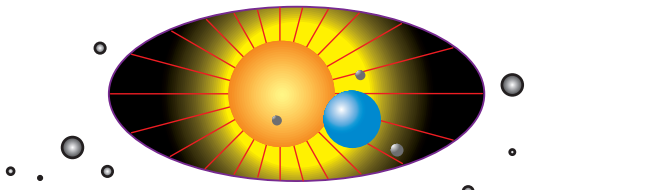
Radiation Budget



MARCH 1998

Fortieth Anniversary
Pioneering the Future



Radiation Budget

LESSON PLANS

Intermediate Grade Levels (5-8)

SCIENCE - Albedo

TECHNOLOGY
Earth's Radiation Budget

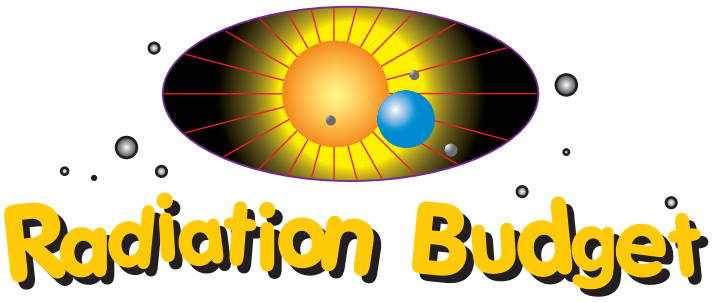
INTEGRATED LANGUAGE ARTS

MATHEMATICS

CUMULATIVE FOLLOW-UP ACTIVITIES

GLOSSARY

GENERAL INFORMATION
Related NASA Web Sites



INTRODUCTION

The NASA's Earth Observing System Data and Information (EOSDIS) and the Distributed Active Archive Center (DAAC) located at Langley Research Center have developed a set of six trading cards to help students learn about the Earth's radiation budget. The Earth's radiation budget is a simple tool that uses the amount of energy the Earth receives from the sun and the amount of energy the Earth sends back to space. If the Earth receives more solar energy than it sends back to space, we expect the Earth to warm up. If the Earth sends more solar energy than it receives from the sun, we expect the Earth to cool down.

To assist educators with teaching the concept of the Earth's Radiation Budget, lesson plans have been developed by teachers and scientists to supplement the content of the trading cards and to integrate these concepts into their curriculum. At the elementary and secondary levels, it is NASA's desire to enhance the knowledge, skills, and experience of teachers to capture the interest of Earth Science into integrated applications of science, mathematics, technology, and related subject matter.

We strongly hope that educators and students enjoy the Earth's Radiation Budget Trading Cards and the activities that accompany them. We also invite you to view the trading cards and lesson plans on the Langley DAAC's Web Site at:

http://eosweb.larc.nasa.gov/education/Erb_Intro.html

Future sets of trading cards will focus on Aerosols (volcanoes, desert-dust, and human-made), Atmospheric Chemistry (greenhouse gases, ozone, and layers of the atmosphere), and Clouds.

Radiation Budget

TRADING CARDS LESSON

S C I E N C E L A B F O C U S

Exploring Albedo

Recommended Age:
Intermediate Level (Grade 5-8)

Guiding Question:
What effect does albedo have on surface temperature?

Objectives

Concepts:

Albedo is the fraction of incoming sunlight that is reflected, rather than absorbed.

Principles:

1. Albedo is represented as a percent of the Earth's total incoming energy. Thus, an albedo of 50% would indicate that half of all incoming radiation is reflected. In general, the more radiation that is reflected usually means lower overall surface temperatures.

2. Albedo represents an important aspect of the *radiation budget*.

3. The Earth's radiation budget is a simple tool that uses the amount of energy the Earth receives from the sun and the amount of energy the Earth sends back to space.

*** If the Earth receives more solar energy than it sends back to space, we expect the Earth to warm up. If the earth sends more energy than it receives from the sun, we expect the Earth to cool down.**

4. In general, more lightly-colored surfaces (snow and ice, for example) have a higher albedo than darker-colored ones (trees, blacktop, etc).

Facts:

1. The overall albedo of the Earth is thought to be about 30%.
2. ERBE instruments collect data concerning the Earth's albedo.
3. The concept of albedo explains (for example) why white robes are favored in desert regions.

Skills:

1. Experimenting & making measurements
2. Drawing conclusions

Applicable National Standards (Science, Level 5-8):

1. Standard B, "Transfer of Energy," items 1, 5, and especially 3 & 6
2. Standard D, "Structure of the Earth System," item 10

Radiation Budget

TRADING CARDS LESSON

SCIENCE LAB FOCUS

Exploring Albedo

Preparation

Materials:

1. Thermometers (3 per lab team)

2. Colored paper (black) and white paper (1 sheet each per lab team)

3. One paper cup of water per lab team

4. Earth Radiation Budget trading card set

Room Preparation:

As most of the lesson will take place outside, no room preparation is necessary. In the absence of warm, sunny weather, the room can be set up with a number of high-intensity lamps as "suns".

[Note: The number of sun lamps will depend on how many students and how many groups are working on the activity. It is suggested that there should be one lamp per group.]

Safety Precautions:

1. Students should report broken thermometers immediately--both broken glass and mercury have a high hazard potential.

2. If lamps are used, make sure students are careful not to let clothes or skin touch the bulb or metal shade (if any).

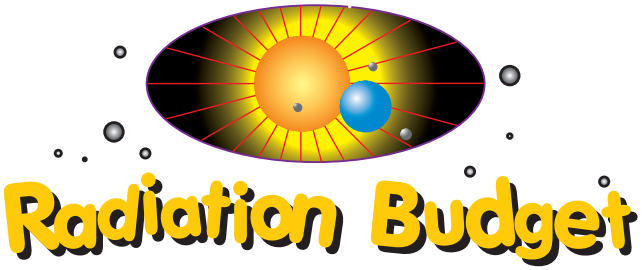
Procedures & Activity

Prelab discussion:

1. Introduce the Earth radiation budget trading cards so students will understand the concept of radiation budget, and the Data card in particular as it explains albedo.

2. Ask students if they would be hotter on a sunny day wearing black or white colored clothes. Ask why they think so, attempting to guide them into realizing that because white is "brighter" (i.e., has a higher albedo), it is correspondingly cooler; black garments reflect little sunlight and are thus warmer.

3. Review variables - independent and dependent.



TRADING CARDS LESSON

SCIENCE LAB FOCUS

Exploring Albedo

Activity:

1. Distribute materials among students. Each lab team should wrap one thermometer tightly in black paper. A second thermometer should be wrapped tightly in white paper, and the third thermometer should be submerged in the cup of water. All three thermometers should then be put in the sun (or underneath the lamp).

2. The temperature readings for all three thermometers should be checked and recorded every five minutes, for a total of 10 minutes. At the end of the first 5-minute waiting period, students should rank the three materials (white paper, black paper, and water) in order, from the highest to the lowest albedo, as a working hypothesis.

3. Each of the three materials (white paper, black paper, and water) should be rated for albedo again at the end of the second 5-minute waiting period, this time using the idea that a higher albedo will yield a lower final temperature.

4. At the end of the final 5-minute waiting period, students should rank the three materials (white paper, black paper, and water), this time using the idea that half of all incoming radiation is reflected; the less radiation that is reflected, the higher overall surface temperature is expected.

Discussion:

1. Which final temperature was the highest? Which was the lowest? Did your results turn out the way you expected?

2. Just in case: If the final temperature for the water proves to exceed that for the black paper, try to get the students to understand the fact that the black paper "shields" its thermometer and thus might have influenced the results. Ask for suggestions on how to redesign the experiment to account for this (an example of a more accurate method is given under "Extension Ideas," below). Have students make inference or have them state the connection between this experiment and the concept listed on the trading cards.

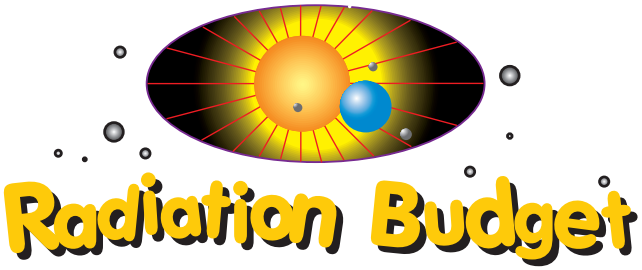
Closing

Ask,"What effect does albedo have on surface temperature?"

Evaluation

1. Completion of lab activity sheets;

2. Did each student contribute equally to the group effort? You may wish to add a question to each activity sheet, along the lines of, "How did you divide up the work?"



TRADING CARDS LESSON

SCIENCE LAB FOCUS

Exploring Albedo

Extension Ideas

1. Have students graph temperature vs. time for all three thermometers, and ask if all three warmed up at the same *rate.*

2. A more accurate method of determining albedo-temperature-color relationships would be to put each thermometer in a cup filled with either cola, milk, or plain water. Make sure that the starting temperatures of all three liquids are identical, and that the volumes of the three are more or less equivalent. You might wish to run the experiment this way after completing it as described above, and allow students to compare results.

3. Assume (for the sake of this experiment) that the black paper (or cola) has an albedo of 0%. Further assume that the albedo of the white paper (or milk) is 100%. Have students interpolate the temperature for the Earth in general (30% albedo) under similar light conditions, based on the two end-point temperatures.

Interpolated Temperature (30%) = 100% albedo temperature + (0.3) x (0% temperature - 100 % temperature)

The Data trading card or Data web page will support further understanding of this concept.

Careers Related to the Lesson Topics

1. Atmospheric scientist

2. Land-use management

3. Climatologist

4. Optical Physicist

Radiation Budget

STUDENT LAB SHEET

EXPLORING ALBEDO

Lab Team

_____ _____

_____ _____

Variables

_____ _____

(dependent) **(independent)**

Data Table

Write out the procedures for testing your hypothesis.

Thermometer covering	Hypothetical Albedo (Highest, middle, lowest)	Temperature after 5 minutes (°C)	Temperature after 10 minutes (°C)	Experimental Albedo (Highest, middle, lowest)
Black paper or cola				
White paper or milk				
Plain water				

Radiation Budget

STUDENT LAB SHEET

EXPLORING ALBEDO

Questions

1

Were your original guesses about the albedo of the different materials supported by the results of the experiment? (check one)

- **Yes; all guesses were proven to be correct.**
- **Somewhat; 1 guess was correct**
- **Not at all; none of the guesses matched the experimental results.**

2

If you checked the second or third box in question 1, why do you think the experimental results were different from your hypothetical results?

_____

_____

If you checked the first box in question 1, why did you originally rate the albedos in the order you did?

_____

_____

3

Which of the following areas would be the coolest on a sunny summer day? Which would be the warmest?

_____	_____	_____
Park with Grass & trees	**City with blacktop**	**Inside of a white building**

Radiation Budget

TRADING CARDS LESSON

SCIENCE & TECHNOLOGY FOCUS

Satellites and the Radiation Budget

Recommended Age:
Intermediate Level (Grade 5-8)

Guiding Question:
How is the Earth's radiation budget studied?

Objectives

Concepts:

NASA uses satellites and remote sensing technology to study the Earth's radiation budget. Data and imaging from these missions are available on-line from the NASA Distributed Active Archive Centers (DAAC) as well as other sources.

Principles:

1. See previous sheet or the web

2. NASA uses satellites to study the Earth's radiation budget.

3. Satellites are used in studying the Earth's radiation budget because it is easier to get a look at planet Earth from space than it is from the Earth's surface. Scientists are increasingly coming to believe that it is important to see the entire Earth as one system, instead of as a number of interrelated parts.

4. The use of satellites is a form of "remote sensing," meaning that data is collected from afar.

5. Each satellite contains a number of instruments which detect different measurements.

Facts:

1. ERBE (Earth Radiation Budget Experiment) instruments were flown on three satellites: ERBS(Earth Radiation Budget Satellite), NOAA-9, and NOAA-10.

2. ERBS scanner instruments have 3 detectors: long-wave radiation, short-wave radiation, and total energy. A scannner instrument moves,"scanning" back and forth, across the satellite's path.

3. The non-scanner instrument gives a wider view than a scanner instrument, but the view is fixed on a point below the satellite (it does not scan back and forth). An ERBE non-scanner instrument contains different radiation detectors.

4. The ERBS satellite was deployed by astronaut Sally Ride.

Radiation Budget

TRADING CARDS LESSON

SCIENCE & TECHNOLOGY FOCUS

Satellites and the Radiation Budget

Objectives

Skills:

1. Conducting research

2. Using technology (the Internet)

Applicable National Standards (Science, Level 5-8):

1. Standard A, "Understanding about scientific inquiry," items 4 & 6

2. Standard B, "Transfer of Energy," items 3 & 6

3. Standard D, "Earth in the Solar System," item 4

4. Standard E, "Understanding about Science and Technology," items 3 & 5

5. Standard G, "Nature of Science," item 1

Preparation

Materials:

1. Trading card set(s)

2. One computer per pair of student group, with Internet access.

Room Preparation:

Log on to the Internet in advance, to save waiting time. The teacher may also wish to assign students to groups, rather than allowing the students to choose.

Safety Precautions:

1. The Internet is to be used to complete the assignments, not to "surf" at random.

2. Remind the students that computers are fragile--no food, drink or horseplay will be tolerated.

Radiation Budget

TRADING CARDS LESSON

SCIENCE & TECHNOLOGY FOCUS

Satellites and the Radiation Budget

Procedures & Activity

Prelab Discussion:

1. The concept of the radiation budget should have already been introduced.

2. Explain that NASA scientists study the radiation budget to determine if certain problems (such as global warming) exist, and if so, what should be done about them.

Listed are some suggested questions for the prelab discussion:

1. **What is the radiation budget?**
2. **Why is it important to study the radiation budget?**
3. **Who do you think studies radiation budget now? Where?**
4. **How do you think they go about studying the radiation budget, when they need to look at the entire Earth?**

Activity:

1. Distribute one card or print information from the trading cards on-line (Introduction, Science, Mission, Satellite, or Data) and the corresponding activity sheet to each group of students. For normal class size, you might photocopy the cards so as to allow smaller group sizes (pairs are optimal), with more than one group working on each card (of course, the number of groups possible is limited by the number of computer terminals with Internet access you have). If there is a small number of terminals, larger groups can be accommodated by handing out more than one card and activity sheet per group.

2. Explain that groups are to use the card and the Internet to answer a set of questions provided (the activity sheet). These questions will be fact-based and require application of skills (e.g., "Find the Web site where..."). You may wish to set a time limit, to further discourage idle "browsing."

3. Students in the lower grades will need more help with the web searches; the teacher may want to provide exact URL's rather than to have the students start at the home pages and search from there.

Activity I - Use with the Introduction Trading Card

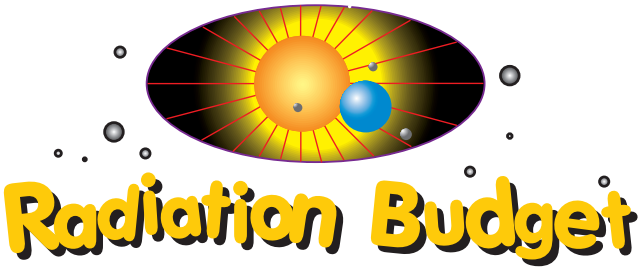
Activity II - Use with the Science Trading Card

Activity III - Use with the Mission Trading Card

Activity IV - Use with the Satellite Trading Card

Activity V - Use with the Instrument Trading Card

Activity VI - Use with the Data Trading Card



TRADING CARDS LESSON

SCIENCE & TECHNOLOGY FOCUS

Satellites and the Radiation Budget

Discussion:

1. Did you find it easy to use the Internet to find the information you needed? Why or why not?

2. Did you encounter any major problems?

3. What did you learn about your trading card topic (other than the answers to your set of questions)?

4. Did you realize that, using the NASA DAAC's Web Site at Langley Research Center, scientists from all over the world can get data directly from NASA?

Closing:

Ask again, "How is the Earth's radiation budget studied?"

Evaluation

1. Completion of lab activity sheets.

2. Did each student contribute equally to the group effort? You may wish to add a question to each activity sheet, along the lines of, "How did you divide up the work?"

Extension Ideas

1. Have students use the Internet––NASA's Web Sites to research other satellite missions.

2. Discuss the history of satellite use, from Sputnik to EOS-1.

Careers Related to the Lesson Topic

1. Atmospheric Scientist

2. Astronaut

3. Aerospace Engineer

... and many others.

Radiation Budget

ACTIVITY SHEET

SATELLITES AND THE RADIATION BUDGET

Lab Team

_____ _____

_____ _____

Trading Card Topic

Introduction

Questions to Complete

1

What is meant by the term "radiation budget"?

_____

_____

2

Find a Web Site (from the list below) that deals with the concept of the radiation budget.

URL: _____

3

What must the Earth do to balance the energy coming from the Sun?

_____

4

Why do NASA scientists study the radiation budget?

_____

_____

5

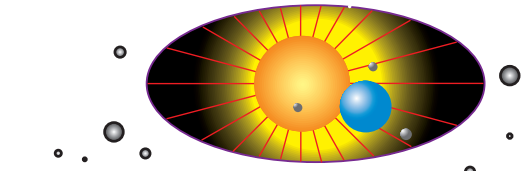
How can you obtain more information about topics related to these questions?

_____

_____

Helpful Web Sites

http://eosweb.larc.nasa.gov
http://asd-www.larc.nasa.gov/erbe/ASDerbe.html
http://asd-www.larc.nasa.gov/erbe/components2.gif



ACTIVITY SHEET

SATELLITES AND THE RADIATION BUDGET

Answer Sheet

Trading Card Topic

INTRODUCTION

1. What is meant by the term "radiation budget?"

Radiation budget is a comparison of how much sunlight reaches the Earth vs. how much heat the Earth gives off into space.

2. Find a Web Site dealing with the concept of the radiation budget.

http://asd-www.larc.nasa.gov/erbe/ASDerbe.html or http://asd-www.larc.nasa.gov/erbe/components2.gif

3. What must the Earth do to balance the energy coming from the Sun?

The Earth must reflect enough energy back into space to keep the temperature from getting too warm or too cold.

4. Why do NASA scientists study the radiation budget?

Studying the Earth's radiation budget is important because it helps scientists better understand how the Earth's climate works.

5. How can you obtain more information about topics related to these questions?

You can obtain more information about topics related to these questions by contacting the Langley DAAC [http://eosweb.larc.nasa.gov]

Radiation Budget

ACTIVITY SHEET

SATELLITES AND THE RADIATION BUDGET

Lab Team

_____ _____

_____ _____

Trading Card Topic

Science

Questions to Complete

1

Where does most of the energy that reaches the Earth come from?
(Hint: this energy is in the form of short-wave radiation**)**

_____

2

From the list find a Web Site dealing with long-wave radiation.

URL: _____

3

Find a picture on the Internet illustrating your answer to #1 and print it.
(If you do not have access to a printer, find an image and ask your teacher to check it for you. If you do not have Internet access at all, draw a picture instead).

4

What determines the characteristics of an electromagnetic wave?

_____

5

How can you obtain more information about topics related to these questions?

_____

_____

Helpful Web Sites

http://eosweb.larc.nasa.gov
http://asd-www.larc.nasa.gov/erbe/ASDerbe.html
http://umbra.nascom.nasa.gov/images/latest_eit_304.gif

Radiation Budget

ACTIVITY SHEET

SATELLITES AND THE RADIATION BUDGET

Answer Sheet

Trading Card Topic

SCIENCE

1. Where does most of the energy that reaches the Earth come from?

The Earth receives most of its energy from the sun.

2. Find the Web Site dealing with long-wave radiation.

http://asd-www.larc.nasa.gov/erbe/ASDerebe.html

3. Find a picture on the Internet illustrating your answer to #1 and print it.

http://umbra.nascom.nasa.gov/images/latest_eit_304.gif

4. What determines the characteristics of an electromagnetic wave?

Wavelengths determine the characteristics of an electromagnetic wave.

5. How can you obtain more information about topics related to these questions?

You can obtain more information about topics related to these questions by contacting the Langley DAAC [http://eosweb.larc.nasa.gov]

Radiation Budget

ACTIVITY SHEET

SATELLITES AND THE RADIATION BUDGET

Lab Team

_____ _____

_____ _____

Trading Card Topic

Mission

Questions to Complete

1

Name one NASA project designed to study the Earth's radiation budget.

_____

2

From the list below, here would you look for information about NASA's ERBE Mission?

URL: _____

3

Name three (3) satellites used in this mission.

_____ _____ _____

4

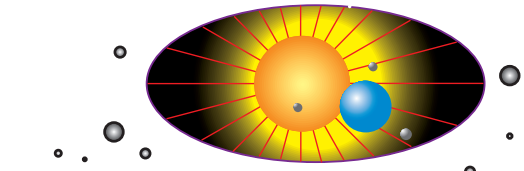
How can you obtain more information about topics related to these questions?

_____

_____

Helpful Web Sites

http://eosweb.larc.nasa.gov
http://www.hq.nasa.gov/office/mtpe/
http://asd-www.larc.nasa.gov/erbe/ASDerbe.html



ACTIVITY SHEET

SATELLITES AND THE RADIATION BUDGET

Answer Sheet

Trading Card Topic

MISSION

1. Name one NASA project designed to study the Earth's radiation budget?

ERBE (Earth Radiation Budget Experiment) is one of NASA's projects designed to study the Earth's radiation budget.

2. Where would you look for information about NASA's ERBE Mission?

http://asd-www.larc.nasa.gov/erbe/ASDerbe.html

3. Name three (3) satellites used in this mission.

ERBS (Earth Radiation Budget Satellite), NOAA-9 (National Oceanic and Atmospheric Administration), and NOAA-10 are the three satellites used in this mission.

4. Mission to Planet Earth recently changed its name to _____.

Mission to Planet Earth (MTPE) recently changed its name to Earth Science Enterprise

5. How can you obtain more information on topics related to these questions?

You can obtain more information about topics related to these questions by contacting the Langley DAAC [http://eosweb.larc.nasa.gov]

Radiation Budget

ACTIVITY SHEET

SATELLITES AND THE RADIATION BUDGET

Lab Team

_____ _____

_____ _____

Trading Card Topic

Satellite

Questions to Complete

1

How did the Earth Radiation Budget Satellite (ERBS) get into space?

_____

2

Who was the astronaut who deployed the satellite?

_____

3

Find a picture of ERBS on the Web and print it.

(If you do not have access to a printer, find an image and ask your teacher to check it for you. If you do not have Internet access at all, draw a picture instead).

4

Why does NASA use satellites to study the radiation budget?

_____

5

How can you obtain more information about topics related to these questions?

_____

_____

Helpful Web Sites

http://eosweb.larc.nasa.gov
http://asd-www.larc.nasa.gov/erbe/ASDerbe.html
http://asd-www.larc.nasa.gov/erbe/erbs.html

Radiation Budget

ACTIVITY SHEET

SATELLITES AND THE RADIATION BUDGET

Answer Sheet

Trading Card Topic

SATELLITE

1. How did the Earth Radiation Budget Satellite (ERBS) get into space?

The ERBS (Earth Radiation Budget Satellite) was launched by the Space Shuttle Challenger. [May also accept a more general answer, such as by way of a rocket.]

2. Who was the astronaut who deployed the satellite?

Sally Ride was the astronaut who deployed the satellite.

3. Find a picture of ERBS on the Web and print it.

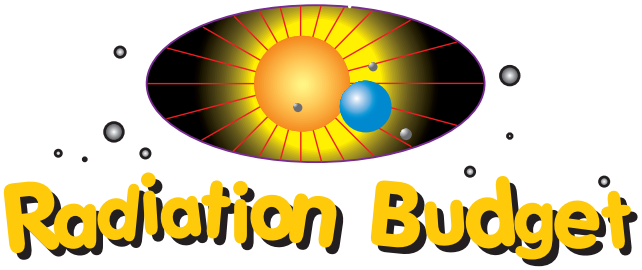
Path to the answer: http://asd-www.larc.nasa.gov/erbe/ASDerbe.htnl; click on ERBS (in the first paragraph); then click on "ERBS" for the satellite image, which is http://asd-www.larc.nasa.gov/erbe/erbssat.gif

4. Why does NASA use satellites to study the radiation budget?

NASA uses satellites to study the radiation budget in order to better understand how the Earth's climate works;Satellites also collect data from the entire Earth and are carried into space by rockets.

5. How can you obtain more information on topics related to these questions?

You can obtain more information about topics related to these questions by contacting the Langley DAAC [http://eosweb.larc.nasa.gov]



ACTIVITY SHEET

SATELLITES AND THE RADIATION BUDGET

Lab Team

_____ _____

_____ _____

Trading Card Topic

Instrument

Questions to Complete

1

What three (3) instruments did ERBS carry?

_____ _____ _____

2

What are these instruments used to study?

_____

3

What is the difference between a scanner instrument and a non-scanner instrument?
(Hint: You may NOT just say, "The scanner scans and the non-scanner doesn't."
You must explain your answer!**)**

_____

4

How long was the ERBS scanner in operation?

(use the Helpful Web Sites to assist you.)

_____

5

How can you obtain more information about topics related to these questions?

_____

Helpful Web Sites

http://eosweb.larc.nasa.gov
http://www.hq.nasa.gov/office/mtpe/
http://asd-www.larc.nasa.gov/erbe/ASDerbe.html

Radiation Budget

ACTIVITY SHEET

SATELLITES AND THE RADIATION BUDGET

Answer Sheet

Trading Card Topic

INSTRUMENT

1. **What 3 instruments did ERBS carry?**
   (Hint: You may need to look at the "Mission" card.)

   1.ERBS (Earth Radiation Budget Satellite)
   2.NOAA-9 (National Oceanic and Atmospheric Administration-9)
   3.NOAA-10 (National Oceanic and Atmospheric Administration-10)

2. **What are these instruments used to study?**

Instruments are used to study light, heat, and total radiation.

3. **What is the difference between a scanner instrument and a non-scanner instrument?**

A scanner instrument moves, sweeping back and forth across the satellite's path as it flies, while the non-scanner instrument collects data from a wide viewpoint.

4. **How long was the ERBS scanner in operation?**

The ERBS scanner was operational for more that five years.
[See http://asd-www.larc.nasa.gov/erbe/erbescanner.html]

5. **How can you obtain more information on topics related to these questions?**

You can obtain more information about topics related to these questions by contacting the Langley DAAC [http://eosweb.larc.nasa.gov]

Radiation Budget

ACTIVITY SHEET

SATELLITES AND THE RADIATION BUDGET

Lab Team

_____ _____

_____ _____

Trading Card Topic

Data

Questions to Complete

1

What is albedo?

_____

2

Find a Web site (from the list below) with a data image showing the surface albedo for January with an 8-year average.

URL: _____

3

What would it mean if there was an albedo of 0%?

_____

4

What would it mean if there was an albedo of 50%?

_____

_____

5

How can you obtain more information about topics related to these questions?

_____

Helpful Web Sites

http://eosweb.larc.nasa.gov
http://agni.larc.nasa.gov/DataSets/sample.html
http://asd-www.larc.nasa.gov/erbe/ASDerbe.html

Radiation Budget

ACTIVITY SHEET

SATELLITES AND THE RADIATION BUDGET

Answer Sheet

Trading Card Topic

DATA

1. What is albedo?

Albedo is the fraction of incoming sunlight that is reflected back into space.

2. Find a Web site (from the list below) with a data image showing the surface albedo for January with an 8-year average.

http://agni.larc.nasa.gov/DataSets/sample.html; or more specifically
http://agni.larc.nasa.gov/DataSets/jan_alb.html

3. What would it mean if there was an albedo of 0% ?

An albedo of 0% indicates that no sunlight is reflected. [See Glossary]

4. What would it mean if there was an albedo of 50% ?

A 50% albedo would indicate that half of all sunlight reaching the Earth is reflected into space.

5. How can you obtain more information about topics to these questions?

You can obtain more information about topics related to these questions by contacting the Langley DAAC [http://eosweb.larc.nasa.gov]

Radiation Budget

LANGUAGE ARTS
INTERDISCIPLINARY LESSONS

A design brief is a unique way of teaching problem solving strategies to students. A problem is given to a student or a group of students, and the work is related to a situation. In most cases, the students either solve or address problems. Design briefs can be integrated across the curriculum. The purpose of a design brief is to teach students how to solve a problem, explore ideas, make a model, and then present it.

Design Brief - Satellite

Pretend that the Earth Radiation Budget Satellite got lost in orbit. Design and build another satellite, with instruments on board, to measure the amount of solar energy received by the Earth and the amount of solar radiation reflected from the Earth into space.

You will have 90 minutes to design and build your satellite in a cooperative group. Your satellite can be of any size, but it must have:
1
"power source"
2
attachable instruments
3
detectors (sensors)

Any of the following materials can be used to construct your product:
milk carton
4 small pieces of aluminum foil
5 straws
10 toothpicks
scissors
markers
clay
tape
construction paper

[optional: **balloon(1) and several rubber bands]**

Radiation Budget

EVALUATION

LANGUAGE ARTS

Satellites

1. After students have constructed their model, have them orally explain the instruments aboard their satellite and its function(s). The students must be able to explain how they designed it, why they decided to make it that way, and how it differs from NASA's Earth Radiation Budget Satellite.

2. Have the students write in their journals about what they did in their groups, and what they contributed to the group. Students could also include what they learned, what puzzled them with the project, what they enjoyed, or what they accomplished in the lesson .

3. Have the students write a descriptive paragraph(s) about the satellite they created and its function(s). Remind the students that their paragraphs must have a topic sentence, supporting sentences, and a concluding sentence.

4. Suggested Journal Topics:

- **Why should scientists know how much radiation is reflected into space?**
- **Should NASA monitor the Earth's radiation budget?**
- **What do you think would happen if a satellite got lost in space?**
- **Explain how the radiation budget is monitored by NASA.**
- **Describe scanning and non-scanning instruments aboard satellites.**
- **How do you think scientists communicate with each other? What is the most effective means?**

Radiation Budget

ACTIVITY SHEET

WORD SEARH PUZZLE

A	S	T	R	O	N	A	U	T	I	O	N	S	C	I
G	H	O	T	S	A	T	E	L	L	I	T	E	N	N
N	U	G	L	R	M	G	P	O	L	D	A	S	H	S
I	T	A	O	A	D	T	S	I	M	E	H	C	C	T
N	E	M	N	U	R	A	D	I	A	T	O	N	N	R
N	S	O	B	Y	R	T	S	I	M	E	H	C	U	U
A	C	R	F	G	N	I	N	N	A	C	S	J	A	M
C	I	T	E	N	G	A	M	O	R	T	C	E	L	E
S	E	M	I	S	S	I	O	N	S	O	A	S	U	N
N	N	S	C	I	T	U	A	N	O	R	E	A	S	T
O	C	Y	S	E	V	S	H	U	T	T	L	E	H	C
N	E	M	I	S	S	I	O	H	O	L	T	S	I	R
O	U	X	P	Y	T	N	E	M	I	R	E	P	X	E

Find the vocabulary words in the word search puzzle

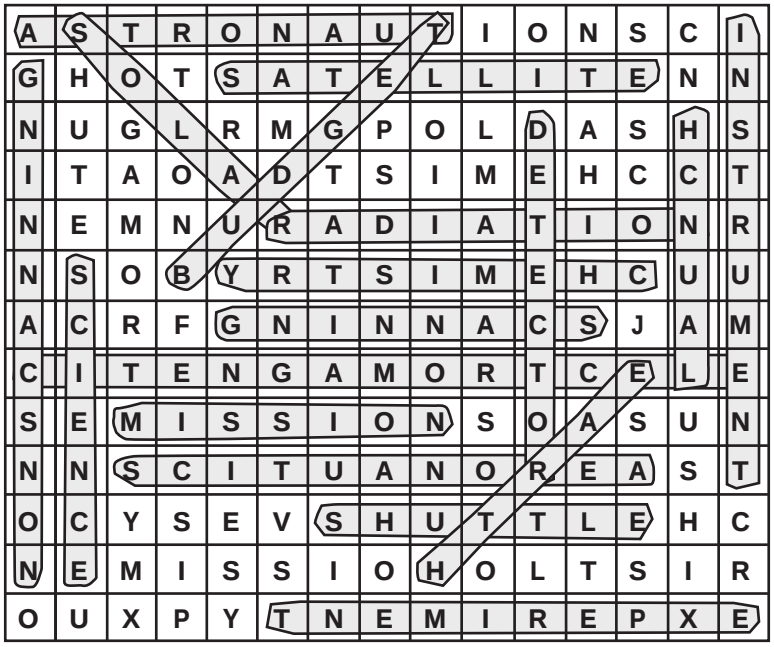
Words can be found backwards, diagonal, horizontal or vertical.

aeronautics
astronaut
budget
chemistry
detector
Earth
electromagnetic
experiment
instrument
launch
mission
non-scanning
radiation
satellite
scanning
science
shuttle
solar

Radiation Budget

ACTIVITY SHEET

WORD SEARH PUZZLE



Radiation Budget

MATHEMATICS
INTERDISCIPLINARY LESSONS

Objective
Develop and apply a variety of strategies to solve problems, with emphasis on multistep nonroutine problems

Instructional Delivery
Cooperative Groups / Flexible Groups / Independent

Materials
The attached *Earth's Energy Budget handout* will be needed for this activity.

Activity

1. Determine the radiation budget by looking at the Earth's Energy Budget.

(Subtract the amount of solar energy from the total amount of reflected energy from the Earth in order to determine the radiation budget).

2. What is the total percentage of the incoming solar energy reflected from the Earth by the atmosphere, clouds, and Earth's surface?

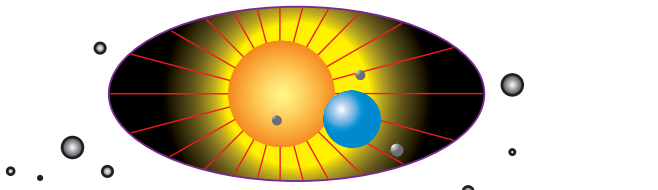
(reflected by: % atmosphere + % clouds + % Earth's surface = _____%

3. Is the total percentage of the incoming solar energy reflected from the atmosphere, clouds, and Earth's surface less than or greater than the incoming solar energy absorbed by the land and oceans?

[(% atmosphere + % clouds + % Earth's surface) < or > (% land + % ocean)]

4. If the amount of incoming solar energy reflected from the Earth's surface tripled, how much energy would be reflected?

(% incoming solar energy) x 3 = _____%



Radiation Budget

EVALUATION

MATHEMATICS

Evaluation

1. Have students (cooperative groups, flexible groups, or independently) create and solve an original mathematical word problem using the information on the *Earth's Energy Budget handout*.

2. Compile student's mathematical word problems for a quiz, or a test or for daily oral math.

Extension Ideas

When introducing the information to the class about the long and short waves, have students estimate and predict wavelengths. Use a piece of yarn or a *slinky* to represent the wavelengths. The students can manipulate the piece of yarn or slinky after making their predictions. This activity may be altered to predict measurement in inches, centimeters, yards, feet, etc.

Answers

The students are to solve the suggested mathematical word problems using the *Earth's Energy Budget handout*. Place questions on index cards and distribute to preferred instructional delivery (cooperative groups, flexible groups or independent).

1. Determine the radiation budget by using the *Earth's Radiation Budget handout*. (Think of the balance instrument when working this problem. Be sure to include figures and percentages you used).

[subtract the amount of solar energy from the total amount or reflected energy from the Earth in order to determine the radiation budget:

100% - (6% + 20% + 4% + 64% + 6%)
100% - 100%
=0%; which represents a balance

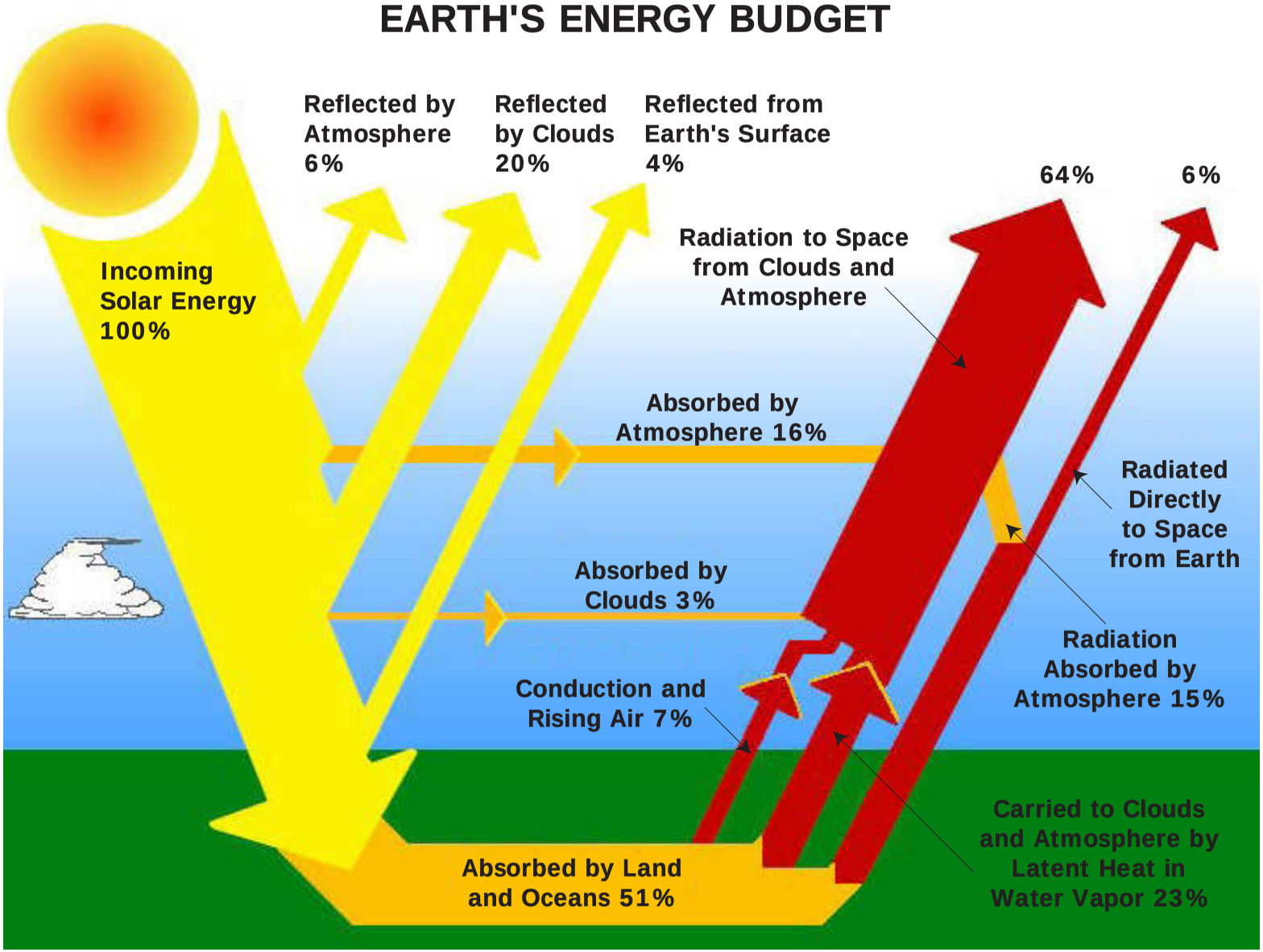
2. What is the total precentage of the incoming solar energy reflected from the Earth by the atmosphere, clouds, and Earth's surface?

[reflected by: atmosphere-6% + clouds-20% + Earth's surface-4% = 30%]

3. Is the total precentage of the incoming solar energy reflected from the atmosphere, clouds, and Earth's surface less than or greater than the incoming solar energy absorbed by the land and oceans?

[(atmosphere, clouds, earth's surface) < (land and ocean)]
30% 51%

4. If the amount of solar energy reflected from the Earth's surface tripled, how much energy would be reflected?
[(4%) x 3 = 12]


EARTH'S ENERGY BUDGET
Reflected by Atmosphere 6%
Reflected by Clouds 20%
Reflected from Earth's Surface 4%
64%
6%
Incoming Solar Energy 100%
Radiation to Space from Clouds and Atmosphere
Absorbed by Atmosphere 16%
Radiated Directly to Space from Earth
Absorbed by Clouds 3%
Radiation Absorbed by Atmosphere 15%
Conduction and Rising Air 7%
Carried to Clouds and Atmosphere by Latent Heat in Water Vapor 23%
Absorbed by Land and Oceans 51%

Radiation Budget

J E O P A R D Y

F O L L O W - U P A C T I V I T Y

Recommended Grades: 5-8

NOTE: The format has been manipulated into questions instead of answers for students unfamiliar with the original game. An asterisk (*) indicates that the Earth's Energy Budget (located by materials needed) page is needed to answer the question. The teacher may need to alter terms for appropriate grade level. However, options are provided.

OBJECTIVE

Recall concepts taught in theme--Earth's Radiation Budget

MATERIALS

***Earth's Energy Budget and trading cards (optional use during game)**

ACTIVITY

Select 3 or 4 students to compete against each other. Illustrate categories and value of points on the chalkboard or poster board. Designate a person to erase or remove the value of points when participants successfully answer the question. It is recommended that the teacher keep score. If the participant successfully answers the question, then the participant receives the points, but if the participant unsuccessfully answers the question, then the points are deducted from his/her score. At that time, any of the other participants can answer to receive the points. Participant should raise their hand in order to indicate that they know the answer. This will prevent all of the participants from speaking at once. The participant that answers the question correctly will select the next category. The participant with the most points can be the challenger for the next set of competitors.

SCIENCE

100 POINTS
- ERBE was deployed by this astronaut. **[Who is Sally Ride?]**
- The comparison of how much sunlight reaches the Earth vs. how much heat the Earth gives off into space. **[What is the "Earth's radiation budget" ?]**

200 POINTS
- Other missions focusing on the radiation budget include what satellite. **[What is CERES?]**
- How are satellites carried into the sky. **[What are rockets or what is space shuttle?]**

300 POINTS
- Two types of ERBE instruments used to study sunlight and the total radiation. **[What are "scanner and non-scanner" instruments ?]**
- Energy in the form of electromagnetic waves. **[What is "radiation"?]**

400 POINTS
- Solar radiation is energy released from the sun in the form of. **[What are "electromagnetic waves"?]**
- An experiment designed to collect information about sunlight reaching the Earth, sunlight reflected by the Earth, and heat released by the Earth into space. **[What is the "Earth Radiation Budget Experiment"?]**

Radiation Budget

J E O P A R D Y

F O L L O W - U P A C T I V I T Y

MATHEMATICS

100 POINTS
- *The percentage of energy absorbed by the atmosphere. **[What is 16% ?]**
- The fraction of incoming sunlight reflected from the Earth, if albedo is 50%. **[What is 1/2 ?]**

200 POINTS
- *Double the percentage of energy absorbed by clouds. **[What is 14% ?]**
- The fraction of incoming sunlight reflected from the Earth, if albedo is 25%. **[What is 1/4 ?]**

300 POINTS
- *Triple the amount of "incoming energy reflected by the atmosphere". Hint: 3a;a=6% **[What is 18% ?]**
- How many years will CERES be in operation. **[What is 2015 - current year ?]**

400 POINTS
- 1/2 of 100% - 50% = . **[What is 0, which represents a balance ?]**
- If 3/4 of all sunlight reaching the Earth is reflected into space, what is the albedo. **[What is 75% ?]**

SPELLING

100 POINTS

s-a-t-e-l-l-i-t-e
r-a-d-i-a-t-i-o-n

200 POINTS

e-x-p-e-r-i-m-e-n-t
l-a-u-n-c-h

300 POINTS

a-s-t-r-o-n-a-u-t
e-l-e-c-t-r-o-m-a-g-n-e-t-i-c w-a-v-e

400 POINTS

E-a-r-t-h / R-a-d-i-a-t-i-o-n / B-u-d-g-e-t
A-e-r-o-n-a-u-t-i-c-s

Radiation Budget

J E O P A R D Y

F O L L O W - U P A C T I V I T Y

ACRONYMS

100 POINTS
- ERBE stands for. **[What is "Earth Radiation Budget Experiment"?]**
- NASA stands for. **[What is National Aeronautics and Space Administration?]**

200 POINTS
- DAAC stands for. **[What is Distributed Active Archive Center?]**
- ERBS stands for. **[What is Earth Radiation Budget Satellite?]**

300 POINTS
- NOAA stands for. **[What is National Oceanic and Atmospheric Administration?]**
- CERES stands for. **[What is Cloud and the Earth's Radiant Energy System?]**

400 POINTS
- SAGE stands for. **[What is Stratospheric Aerosol and Gas Experiment?]**
- EOSDIS stands for. **[What is Earth Observing System Data and Information System?]**

VOCABULARY

100 POINTS
- A person who travels beyond the Earth's atmosphere. **[What is an astronaut?]**
- The amount of sunlight that the Earth reflects into space. **[What is albedo?]**

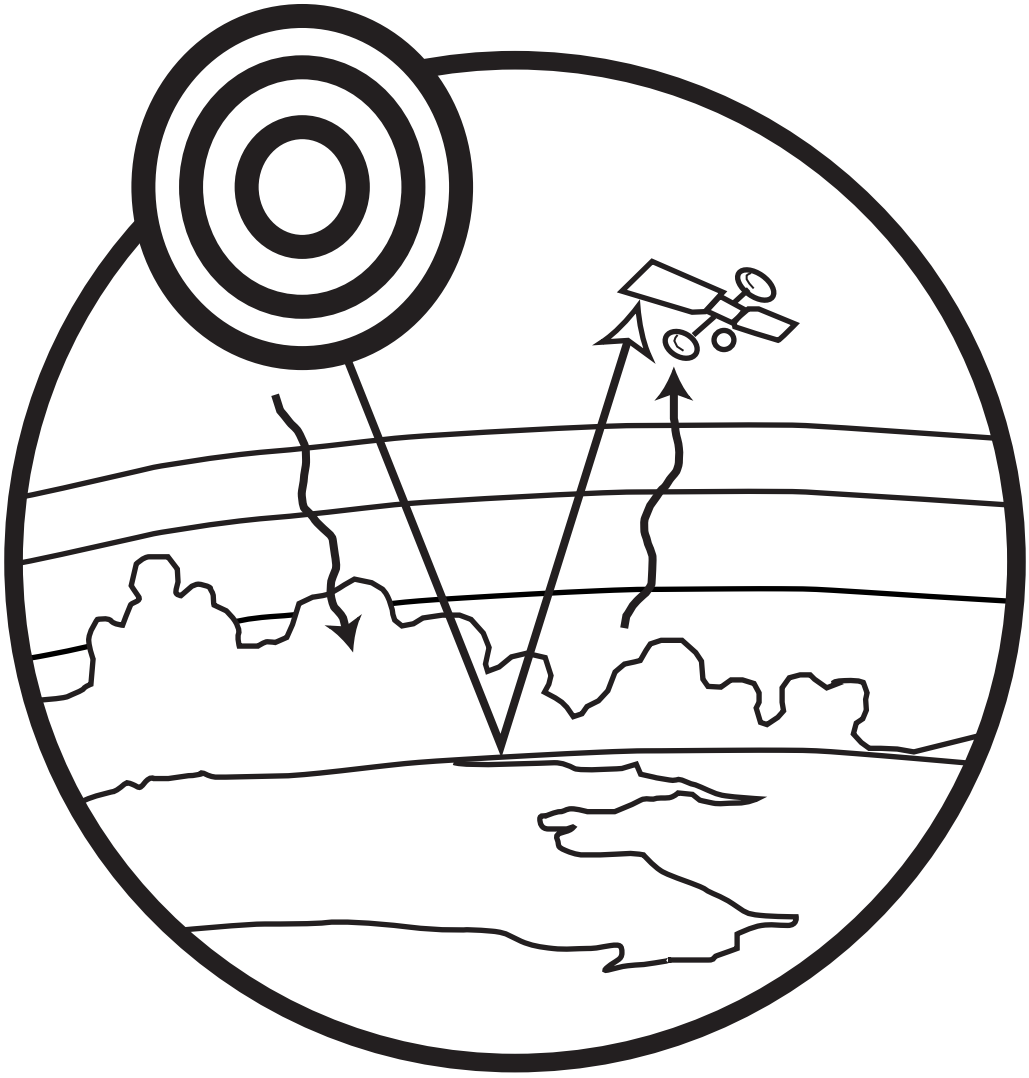
200 POINTS
- A science dealing with the operation of aircraft. **[What is Aeronautics?]**
- A reusable spacecraft designed to transport people and cargo between Earth and space. **[What is a space shuttle?]**

300 POINTS
- A measuring device that sweeps back and forth across a satellite's path as it flies. **[What is a scanner instrument?]**
- An operation carried out under controlled conditions in order to discover an unknown effect of law / to test or establish a hypothesis / to illustrate a known law. **[What is an experiment?]**

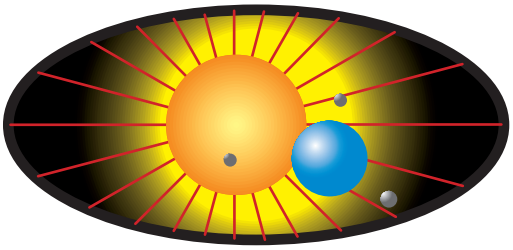
400 POINTS
- A manufactured object designed to orbit the Earth, the moon, or another celestial body. **[What is a satellite?]**
- An aerospace task sent to perform a service or carry an activity. **[What is a mission?]**

*** Use vocabulary words applicable to grade level.**

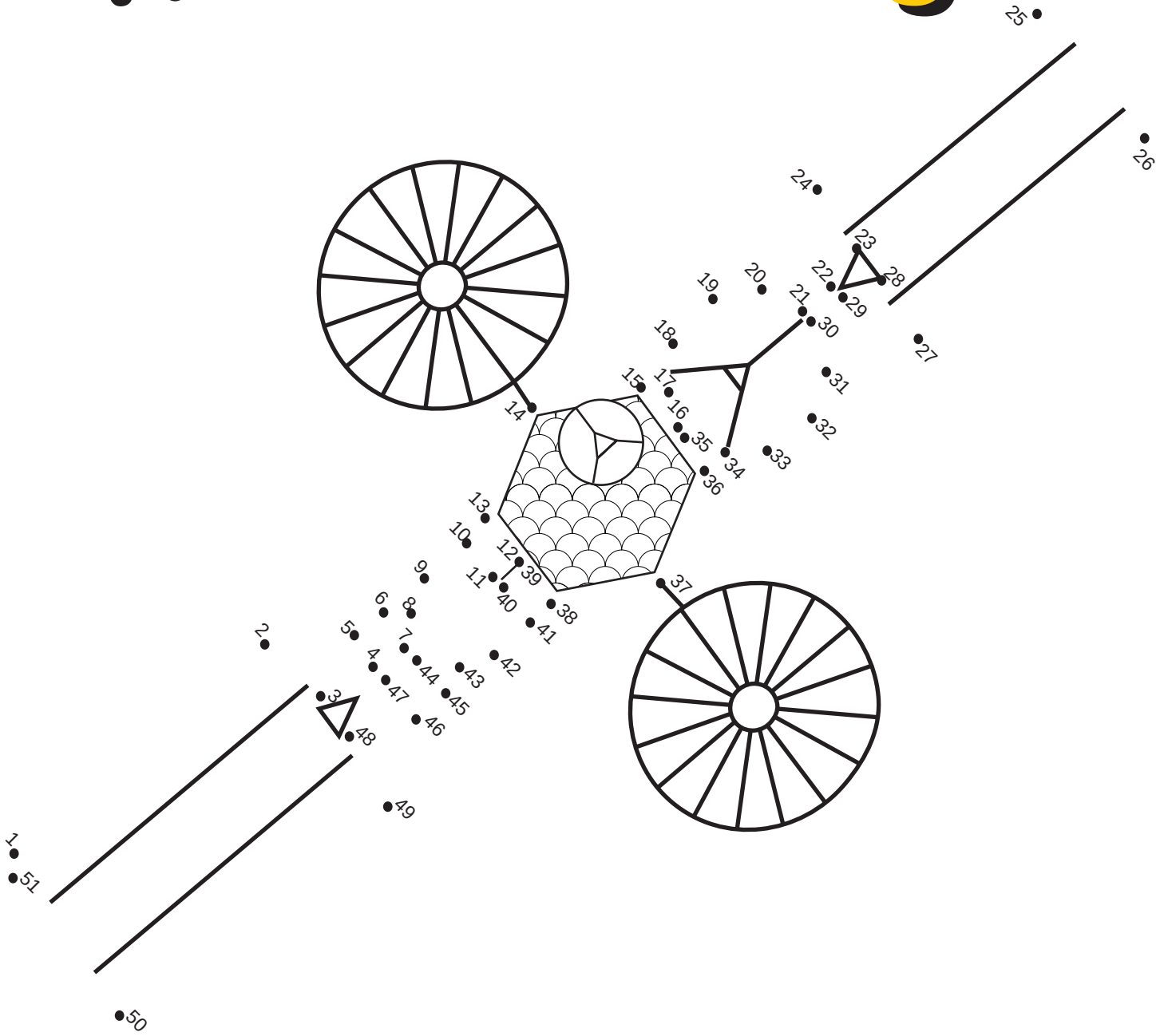
Radiation Budget



The ozone layer, clouds, and dust in the air sometimes block the sun's energy from reaching or leaving the Earth's atmosphere. Why do you think satellites are needed to study this?



Radiation Budget



Satellites can be used to determine what blocks energy from reaching or leaving the Earth's atmosphere. Can you name 3 things that can possibly block the sun's energy from leaving the Earth's atmosphere?

Radiation Budget

MAZERCISE

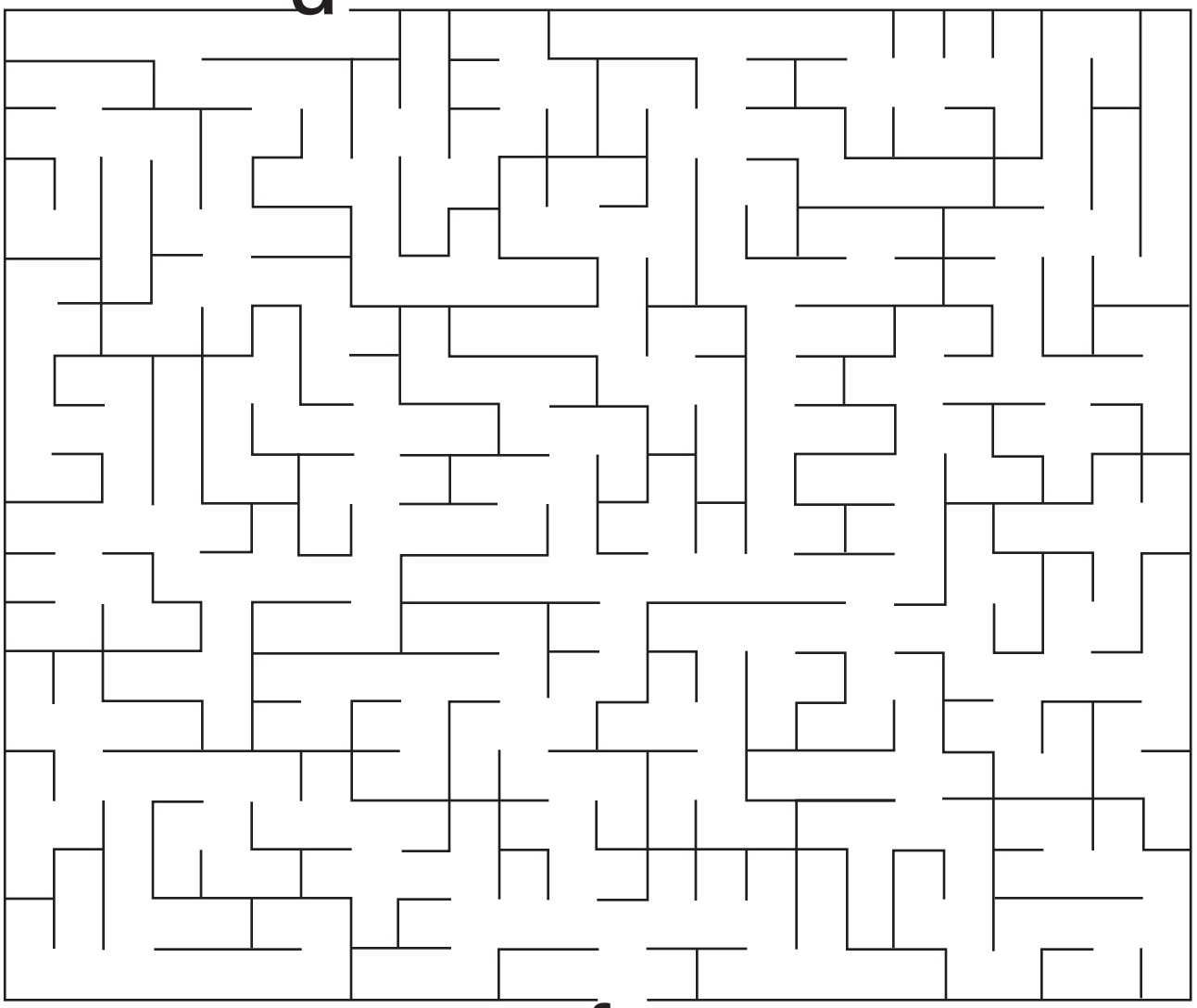
RADIATION BUDGET

Help the scientist receive data (information) from the Earth's Radiation Budget Satellite.

b

ERBS

d



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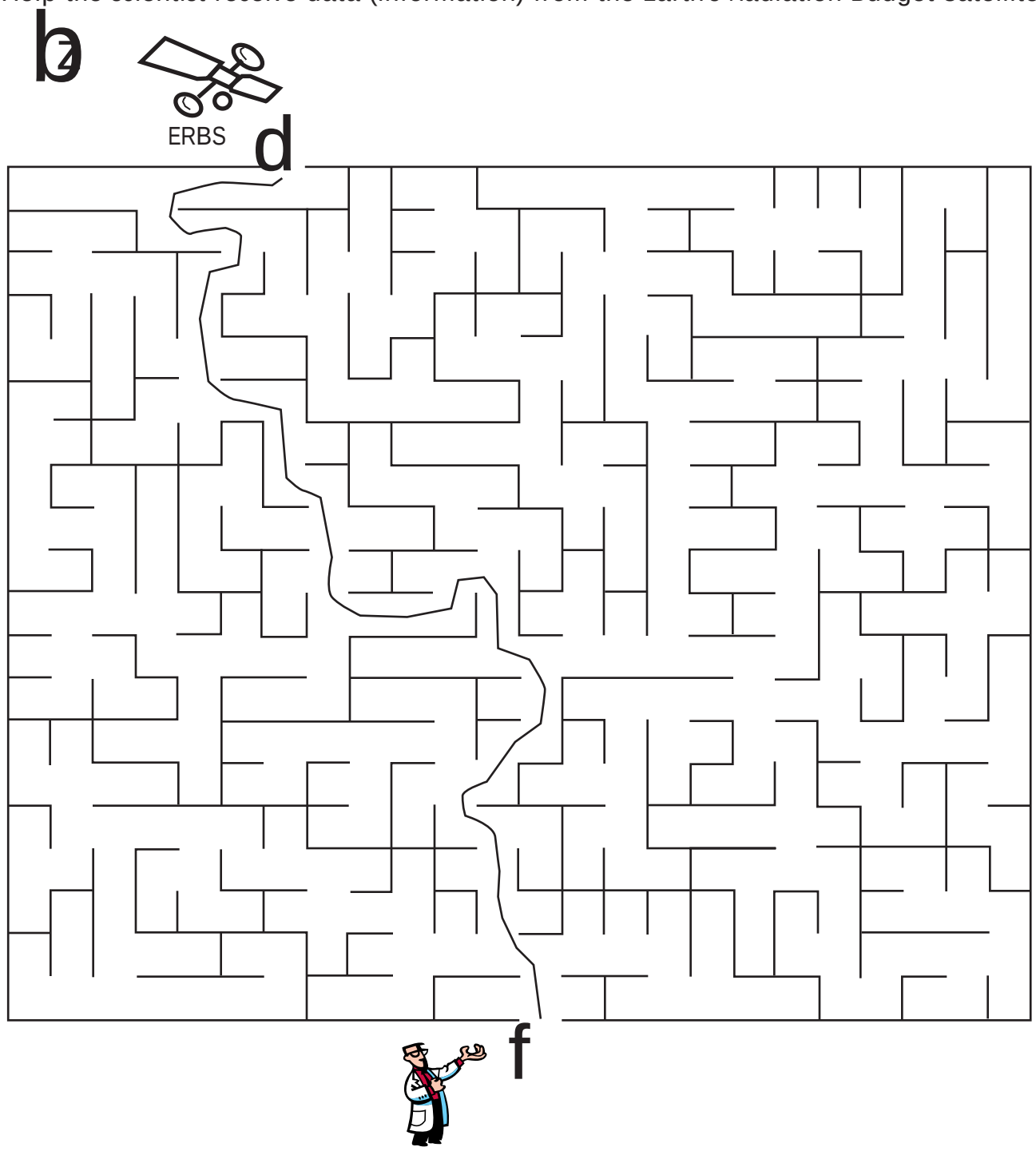
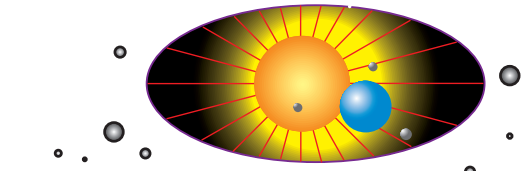
Radiation Budget

MAZERCISE

RADIATION BUDGET

Help the scientist receive data (information) from the Earth's Radiation Budget Satellite.





ACTIVITY SHEET

CROSSWORD PUZZLE

Use the glossary to help you answer the crossword puzzle

ACROSS:

4
Heat Emitted by the earth. It has lower energy (and thus a longer wavelength) than the incoming sunlight.

5
Earth Radiation Budget Experiment. A satellite mission by NASA to study the radiation budget.

6
National Oceanic and Atmospheric Administration. (abbreviation)

9
Earth Radiation ____ Satellite. A NASA satellite carrying instruments used to study the radiation budget.

10
Energy in the form of electromagnetic waves. Various forms of radiation that have characteristics, depending on the wavelength.

13
Earth Observing System and Data and Information System. (abbreviation) Manages, stores, and distributes satellite data.

15
Instrument used to detect short-wave, longwave, and total radiation.

16
The Earth emits long-wave radiation after ___ short-wave radiation from the sun.

17
ERBE's ____ instruments contained 5 detectors measure radiation.

DOWN:

1
Radiation with higher energy (and thus a shorter wavelength) than heat.

2
Type of energy distinct from chemical energy., kinetic energy, etc.

3
National Aeronautics and Space Administration (abbreviation)

7
The fraction in incoming sunlight that is reflected back into space.

8
Cloud and the Earth's Radiation Energy System (abbreviated)

11
Cloud and Earth's Radiation ____ System.

12
The field of view of a scanning ____ moves, sweeping back and forth across the satellite's path.

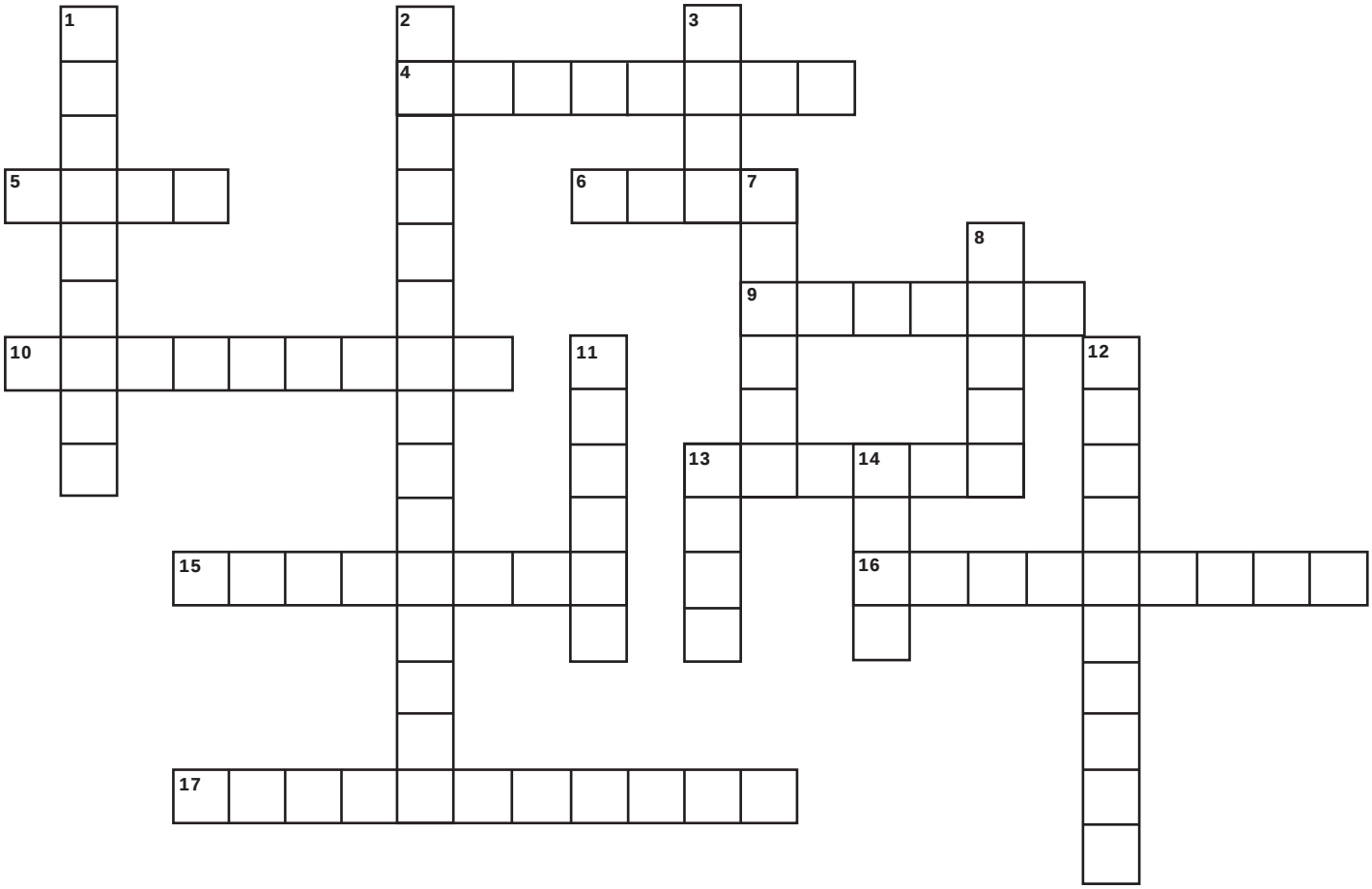
13
To send out.

14
Distributed Active Archive Center (abbreviated)

Radiation Budget

ACTIVITY SHEET

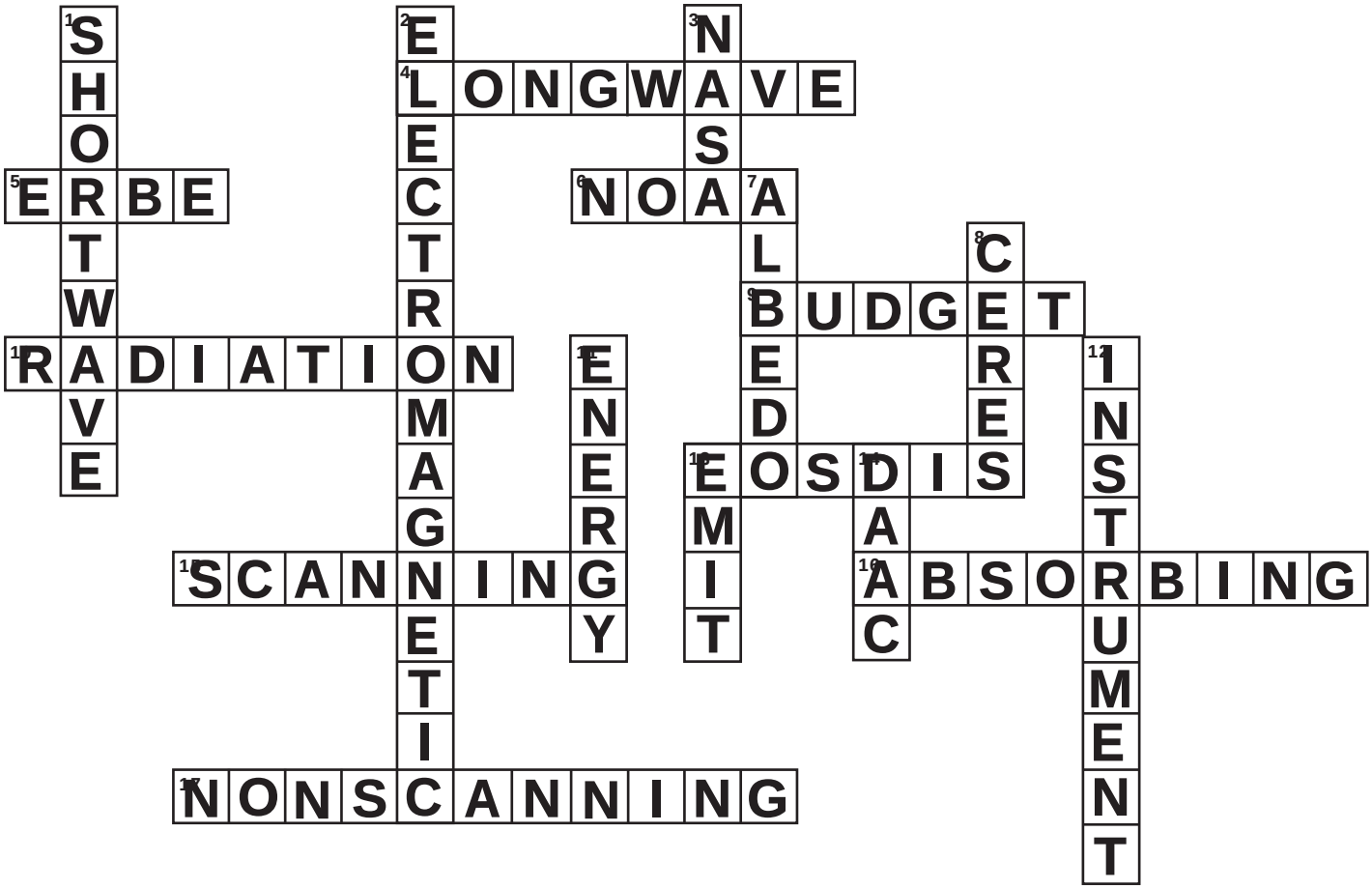
CROSSWORD PUZZLE



Radiation Budget

ACTIVITY SHEET

CROSSWORD PUZZLE



Radiation Budget

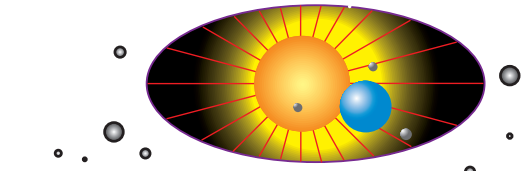
ACTIVITY SHEET

ACRONYM MAP SEARCH

An ACRONYM is a word made from the beginning letters of other words. For example, "SCUBA" is an acronym meaning "Self-Contained Underwater Breathing Apparatus." Scientists at NASA love to use acronyms. In fact, the name "NASA" is an acronym! Do you know what it stands for? On maps, people use LATITUDE and LONGITUDE to help them find where things are located. Latitude means how far north or south something islocated, and is measured in degrees (°). 90° North latitude is the North Pole; 90° South latitude is the South Pole, and 0° latitude is the equator. Longitude is also measured in degrees; it is how far east or west something is located.

Pretend the word search on the next page is a map. Use the latitudes and the longitudes given to find each acronym! (Hint: The coordinates given are for the first letter of the acronym. Acronyms in the puzzle may be forwards, backwards, up and down, or even diagonal).

Acronyms for:	Latitude	Longitude
Clouds and the Earth's Radiant Energy System	75° N	120° E
Distributed Active Archive Center	15° S	120° E
Earth Observing System	60° N	90° E
Earth Radiation Budget Experiment	60° N	30° E
Earth Radiation Budget Satellite	15° S	0° E/W
Goddard Space Flight Center	45° N	0° E/W
International Satellite Cloud Climatography Project	75° S	150° E
International Space Shuttle	0° N/S	60° W
Measurement Of Pollution In The Troposphere	0° N/S	150° W
Earth Science Enterprise	60° N	180° E/W
National Aeronautics and Space Administration	75° N	120° W
National Oceanic and Atmospheric Administration	75° S	150° W
Stratospheric Aerosol and Gas Experiment	15° N	60° W
Total Ozone Mapping Spectrometer	15° N	150° W
Tropical Rainfall Measuring Mission	45° S	60° E
Upper Atmosphere Research Satellite	0° N/S	30° E



ACTIVITY SHEET

ACRONYM MAP SEARCH

Lat./ Long	180° E/W	150° W	120° W	90° W	60° W	30° W	0° E/W	30° E	60° E	90° E	120° E	150° E	180° E/W
75° N	S	B	N	A	S	A	I	S	C	O	C	C	P
60° N	E	E	S	B	R	A	T	E	C	E	R	A	T
45° N	O	S	D	C	F	S	G	D	R	L	O	E	S
30° N	T	S	E	D	S	A	F	E	A	B	A	S	R
15° N	M	T	P	E	S	R	S	C	L	R	E	S	O
0° N/S	R	M	O	P	I	T	T	U	A	O	K	F	T
15° S	T	O	N	M	P	I	E	C	A	A	D	A	A
30° S	E	R	O	L	S	R	C	P	D	R	S	S	C
45° S	P	K	R	A	B	M	M	R	T	A	S	A	D
60° S	O	E	R	S	B	D	A	A	L	M	I	T	P
75° S	L	N	O	A	A	A	C	P	C	C	S	I	L

Checklist:

CERES__ __ISS

GSFC__ __NOAA

ESE__ __ERBE

TRMM__ __EOS

DAAC__ __SAGE

ISCCP__ __ERBS

NASA__ __MOPITT

UARS__ __TOMS

Radiation Budget

ACTIVITY SHEET

ACRONYM MAP SEARCH

Lat./ Long	180° E/W	150° W	120° W	90° W	60° W	30° W	0° E/W	30° E	60° E	90° E	120° E	150° E	180° E/W
75° N	S	B	N	A	S	A	I	S	C	O	C	C	P
60° N	E	E	S	B	R	A	T	E	C	E	R	A	T
45° N	O	S	D	C	F	S	G	D	R	L	O	E	S
30° N	T	S	E	D	S	A	F	E	A	B	A	S	R
15° N	M	T	P	E	S	R	S	C	L	R	E	S	O
0° N/S	R	M	O	P	I	T	T	U	A	O	K	F	T
15° S	T	O	N	M	P	I	E	C	A	A	D	A	A
30° S	E	R	O	L	S	R	C	P	D	R	S	S	C
45° S	P	K	R	A	B	M	M	R	T	A	S	A	D
60° S	O	E	R	S	B	D	A	A	L	M	I	T	P
75° S	L	N	O	A	A	A	C	P	C	C	S	I	L

Checklist:

CERES__ __ISS

GSFC__ __NOAA

ESE__ __ERBE

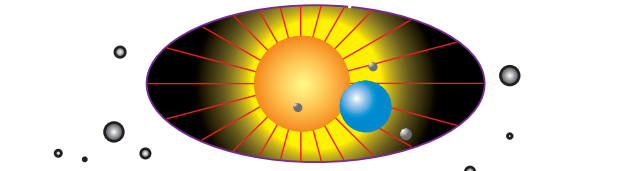
TRMM__ __EOS

DAAC__ __SAGE

ISCCP__ __ERBS

NASA__ __MOPITT

UARS__ __TOMS



ACTIVITY SHEET

RADIATION BUDGET QUESTIONS

Fill in the answers as shown, then put together the circled letters to get the final answer to the question:

What is the balance between incoming sunlight and outgoing heat called?

Hints:

1. NASA mission using satellites to study radiation and its effects on the Earth's climate (acronym). _ □ _ _

2. Astronaut who deployed the ERBS satellite. _ □ _ _ _ _ _ □ _

3. Energy in the form of electromagnetic waves. _ _ _ _ _ _ □ _ _

4. The ERBS satellite carried 2 ERBE instruments, and also the ___-II instrument. _ □ _ _

5. Short-wave radiation received by the Earth. _ _ _ _ _ _ _ □

6. The Radiation Budget Trading Cards include Introduction, Science, Instrument, Data, and: _ _ _ _ □ □ □

7. Fraction of incoming sunlight which gets reflected back into space. _ _ □ _ _ _

8. Source of short-wave radiation. _ □ _

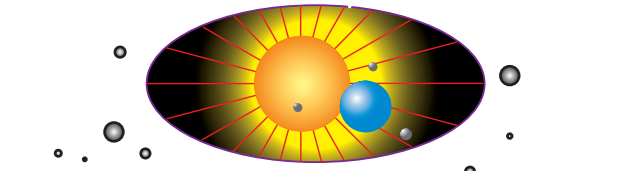
9. Information collected by instruments. □ _ _ _

10. Space Shuttle from which the ERBS satellite was deployed. _ _ _ _ _ _ _ □ _ _

11. ERBE instrument which moves, scanning back and forth. _ _ _ _ _ □ _

12. Long-wave radiation given off by the Earth into space. _ _ _ □

Final Answer:



ACTIVITY SHEET

RADIATION BUDGET QUESTIONS

Fill in the answers as shown, then put together the circled letters to get the final answer to the question:

What is the balance between incoming sunlight and outgoing heat called?

Hints:

1. NASA mission using satellites to study radiation and its effects on the Earth's climate (acronym).

E (R) B E

2. Astronaut who deployed the ERBS satellite.

S (A) L L Y R I (D) E

3. Energy in the form of electromagnetic waves.

R A D I A T (I) O N

4. The ERBS satellite carried 2 ERBE instruments, and also the ___-II instrument.

S (A) G E

5. Short-wave radiation received by the Earth.

S U N L I G H (T)

6. The Radiation Budget Trading Cards include Introduction, Science, Instrument, Data, and:

M I S S I (O) N

7. Fraction of incoming sunlight which gets reflected back into space.

A L (B) E D O

8. Source of short-wave radiation.

S (U) N

9. Information collected by instruments.

(D) A T A

10. Space Shuttle from which the ERBS satellite was deployed.

C H A L L E N (G) E R

11. ERBE instrument which moves, scanning back and forth.

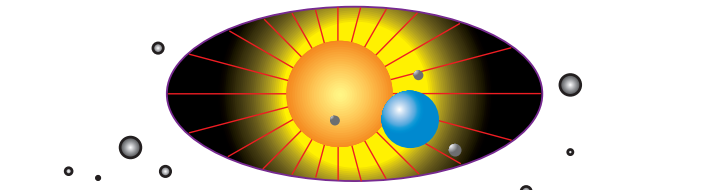
S C A N N (E) R

12. Long-wave radiation given off by the Earth into space.

H E A (T)

Final Answer:

R	A	D	I	A	T	I	O	N	B	U	D	G	E	T



GENERAL INFO

FOR TEACHERS & STUDENTS

IF YOU LIVE IN:	CENTER EDUCATION PROGRAM OFFICE	EDUCATION RESOURCE CENTER
Alaska Arizona Hawaii Idaho Montana Wyoming Nevada California Oregon Utah Washington	Chief, Education Programs Branch Mail Stop 204-12 NASA AMES RESEARCH CENTER Moffett Field, CA 94035	NASA TRC Mail Stop T12-A NASA AMES RESEARCH CENTER Moffett Field, CA 94035 415•604•3574
Connecticut Delaware D.C. Maine Maryland Massachusetts New Hampshire New Jersey New York Pennsylvania Rhode Island Vermont	Educational Programs Mail Code 130 NASA GODDARD SPACE FLIGHT CENTER Greenbelt, MD 20771	NASA TRL Mail Code 130.0 NASA GODDARD SPACE FLIGHT CENTER Greenbelt, MD 20771 301•286•8570
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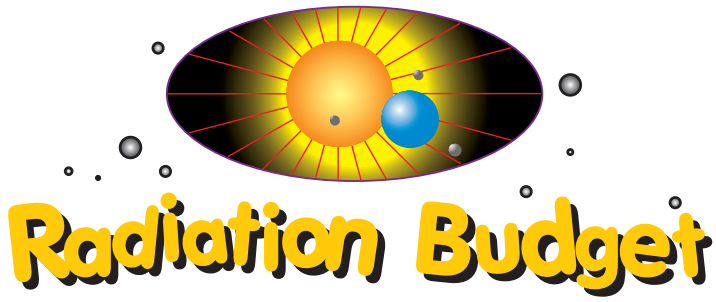
Illinois Indiana Michigan Minnesota Ohio Wisconsin	Acting Chief, Office of Educational Programs Mail Stop 7 - 4 NASA LEWIS RESEARCH CENTER 21000 Brookpark Road Cleveland, OH 44135	NASA Teacher Resource Center for MARSHALL SPACE FLIGHT CENTER U.S. SPACE AND ROCKET CENTER P.O.BOX 070015 Huntsville, AL 35807-7015 205•544•5812
Alabama Arkansas Iowa Louisiana Missouri Tennessee	Director, Education Programs Office (CL-01) NASA MARSHALL SPACE FLIGHT CENTER Huntsville, AL 35812	
The Eastern Shores of Virginia and maryland		Wallops Flight Facility Educational Complex - Visitor Center Building J-17 Wallops Island, VA 23337 804•824•2297 / 2298



GENERAL INFO

FOR TEACHERS & STUDENTS

The NASA Education Division has created the NASA Educator Resource Center (ERC) Network that contains a wealth of information for educators: publications, reference books, slide sets, audio cassettes, videotapes, lecture programs, computer programs, curriculum support materials, and educator guides with activities. Because each NASA Field Center has its own areas of expertise, no two ERCs are alike. Telephone calls are welcomed if you are unable to visit the ERC that serves your geographic area. A list of the Centers and the geographic regions they serve are listed in the table on the previous sheet.

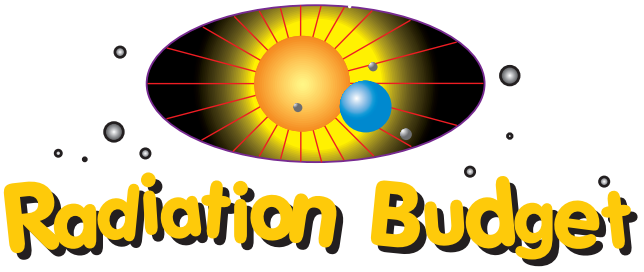
NASA Television features programming that has three program blocks: Education File, History File, and News Video File (repeated at intervals 24 hours a day). Programs feature:

Space Shuttle mission coverage
Live special events
Interactive education videoconferences
Electronic field trips
Aviation and space news
Historical NASA footage

The Education File features programming for teachers and students on science, mathematics, and technology. You and your class can investigate exciting NASA research endeavors in aeronautics, microgravity, planetary sciences, human exploration of space Earth systems, robotics, and more! Educators are welcome to videotape NASA TV. The scheduled times for the Education File are: 2-3 p.m.; 5-6 p.m.; 11 p.m. - 12 a.m.; and 2-3 a.m. (EST).

For more information contact:
NASA TV, NASA Headquarters, Code P
Washington, D.C. 20546
202•358•3572

NASA TV: Spacenet -2, C-Band, T5, Ch.9, 69 degrees west, 3880 MHz horizontal polarization, audio 6.8 MHz.



GENERAL INFO

LIST OF NASA WEB SITES

Langley Distributed Active Archive Center
http://eosweb.larc.nasa.gov

CERES project Home Page
http://asd-www.larc.nasa.gov/ceres/ASDceres.html

ERBS satellite information
http://asd-www.larc.nasa.gov/erbe/erbs.html

ERBE mission information
http://asd-www.larc.nasa.gov/erbe/ASDerbe.html

Earth Science Enterprise
http://www.hq.nasa.gov/office/mtpe/

NOAA satellite image
http://asd-www.larc.nasa.gov/erbe/noaasat.gif

Earth's Energy Budget Diagram
http://asd-www.larc.nasa.gov/erbe/components2.gif

Radiation budget graphics
http://agni.larc.nasa.gov/DataSets/sample.html

Sun images
http://umbra.nascom.nasa.gov/images/latest.html

NASA image exchange
http://nix.nasa.gov/

NASA's Observatorium
http://observe.ivv.nasa.gov/nasa/core.shtml

Space Science
http://observe.ivv.nasa.gov/nasa/space/space_index.shtml

NASA Langley Educator Resource Center
http://www.vasc.org/erc/

NASA Langley DAAC Educational Resources
http://eosweb.larc.nasa.gov/HPDOCS/education.html

NASA Langley Office of Education
http://edu.larc.nasa.gov/